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Demand side management: A green way to power Beijing

Zhijun Zhao,[1] Can Yu,[1,a)] Mona Yew,[2,b)] and Mingming Liu[2,a)]
[1]*Beijing Energy Conservation and Environmental Protection Center, A2 Xiaoguandongli, Chaoyang District, 100029 Beijing, People's Republic of China*
[2]*Natural Resources Defense Council, 40 West 20th Street, New York, New York 10011, USA*

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As a Demand Side Management (DSM) PilotCity, one of four in China, Beijing set an ambitious goal to reduce its peak electricity load by 800 MW over a three-year period from 2013 to 2015. The Beijing Energy Conservation and Environmental Protection Center and Natural Resources Defense Council formed an EcoPartnership in July 2013 to help Beijing achieve this goal by building the DSM implementation capacity within the city. With support from the EcoPartners, the city of Beijing has developed a policy support framework for DSM, launched the DSM Service Platform, and created an electricity services and third party demand response aggregator market. In addition, the EcoPartnership provided opportunities for U.S. service providers to participate in Beijing's nascent DSM market, including sharing program design concepts and implementation models, and developing potential collaboration with local enterprises. DSM is becoming a viable alternative to traditional supply side resources for fulfilling Beijing's power demands in a green and economically efficient way. © *2015 AIP Publishing LLC*. [http://dx.doi.org/10.1063/1.4927149]

I. INTRODUCTION

China has recognized the benefit of demand side management (DSM) in alleviating power constraints and improving power grid operation, as well as the important role cities can play to promote DSM. As such, China's Ministry of Finance and the National Development and Reform Commission (NDRC) launched a Demand Side Management Pilot City program (Interim Measures on Financial Incentives from the Central Government for Demand-Side Management Pilot Program, Ministry of Finance, July 3, 2012)[1] in 2012 and selected four cities—Beijing, Suzhou (Jiangsu Province), Tangshan (Hebei Province), and Foshan (Guanngdong Province)[2]—to demonstrate the value of DSM as a resource. As part of the pilot program, each city set specific targets for power conservation and load shifting to be achieved over a three-year period (2013–2015), as well as provided co-funding in addition to the financial incentives provided by the central government. Beijing proposed to reduce its peak load by 800 MW or approximately 4%–5% of the city's maximum load, focusing primarily on the commercial sector which comprises a key part of Beijing's local economy (http://www.bjpc.gov.cn/tztg/201308/t6493571.htm).[3]

The term "demand side management" refers to modifying how electricity consumers use energy to achieve load reductions (i.e., reduce demand) when power supply is short, thereby deferring the need to construct new power plants or build additional transmission and distribution capacity. DSM measures can include both permanent load reductions from energy efficiency and load shifting measures, as well as short-term load reductions that temporarily shut down energy-using systems and processes such as demand response (DR). While DSM was introduced to China in the 1990s, its application has been limited, and the potential of DSM as

[a)]C. Yu and M. Liu contributed equally to this work.
[b)]Author to whom correspondence should be addressed. Electronic mail: myew@nrdc-china.org.

an alternative to supply side resources has yet to be fully developed. However, momentum is building: The Chinese government introduced a series of policies in recent years to support the promotion of DSM across the country, from the national "Demand Side Management Rules"[4,8] issued at the end of 2010, to the newly released State Council's "Opinions on Deepening Power System Reform."[5,9] China is poised to scale up its DSM efforts and develop a robust DSM market. The successful implementation of DSM programs in Beijing will provide a replicable model for the rest of the country and bring new business opportunities for both international and domestic service providers.

The Beijing Energy Conservation and Environmental Protection Center (BEEC) and Natural Resources Defense Council (NRDC) joined hands under the U.S.-China EcoPartnership program in July 2013 to introduce and adapt DSM best practices from the U.S. to support Beijing's DSM pilot. Through policy study, project design and implementation, training, study exchanges, and other activities, the partnership aims to help Beijing reduce its peak load by 800 MW by 2015 and improve Beijing's energy use in a green and economically efficient way.

II. IMPACT OF ECOPARTNERSHIP ON BOTH COUNTRIES

Beijing is a megapolis of over 20×10^6 people with a sizeable service industry. The commercial sector (Generally referred to as the tertiary industry or service industry in China) has surpassed the industrial sector (Generally referred to as the secondary industry in China) not only in terms of economic contribution but also in power consumption. The gross domestic production (GDP) of Beijing's commercial sector in 2013 comprises 76.9% of the city's total GDP and 44% of its total electricity use (see Figures 1 and 2). Due to Beijing's geographic location, climate, and economic structure, air conditioning load contributes to nearly 40% of the city's summer peak demand. The city's heating load is also continuing to rise and creating a winter peak that is almost as high as the summer peak. In 2013, the city's maximum load reached 17.76 GW in the summer and 15.54 GW in the winter. The large load differential between the daytime peak and the nighttime off-peak periods, coupled with Beijing's dual summer and winter peaks, are straining Beijing's power grid and potentially jeopardizing grid operation safety.

Beijing has also been increasingly plagued by severe air pollution. Coal consumption is one of the major contributors to Beijing's smog problem.[6] While Beijing's Clean Air Initiative[7] has placed limits on local coal combustion, the surrounding areas, including Tianjin and Hebei province, still rely on coal fired power plants to supply electricity and heating. The smog has affected larger areas, lasted longer, and created higher levels of pollution in recent years.

With the pressures to address both power grid management and air pollution issues, Beijing has found DSM to be an effective solution. Through efficiency improvements, load management, demand response, and other DSM measures, the city can bring down its electricity demand and reduce the need for some peak load power production, thus achieving energy conservation and environmental protection in a cost-effective way.

FIG. 1. Industry sector development trend in Beijing (2000–2013). Constant price is calculated using 2000 as the base year using data from Beijing.

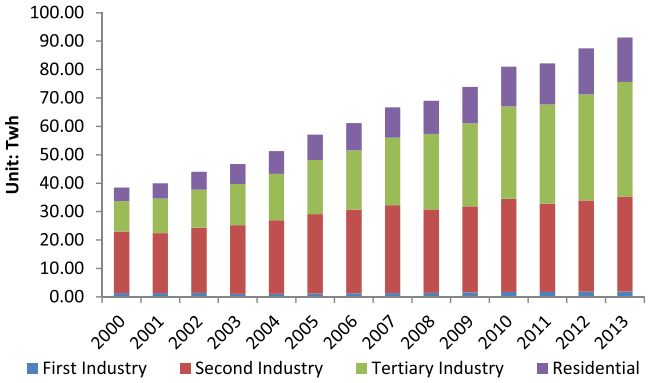

FIG. 2. Power consumption trend in Beijing by industry (2000–2013).

Beijing is not alone. The U.S. has had its share of environmental and pollution challenges, and the U.S. has successfully deployed DSM since the 1980s, including energy efficiency and, in more recent years, demand response. Some states such as California have developed a robust DSM industry and many multinational service providers that are working not only in the U.S. but also in other countries across the globe. The nascent DSM—and in particular demand response—market in China provides new opportunities for U.S. based technology and service providers to share their experience, products, and services with an eager and welcoming audience, and at the same time, learn from China's home-grown innovation.

Against this backdrop, the BEEC-NRDC EcoPartnership is helping Beijing improve its DSM capacity, develop an electricity services market, engage more stakeholders in DSM activities to alleviate peak load constraints in both summer and winter, create a flexible emergency reserve, and address smog concerns. At the same time, NRDC and the BEEC are also working with the China-U.S. Energy Efficiency Alliance (Alliance)—a public-private partnership aimed at engaging industry, government authorities and others for bilateral exchanges of information and experience related to energy efficiency—as the main platform to share relevant developments in China and opportunities for U.S. companies. For example, the Alliance led the organization of the first U.S. Commerce Department certified trade mission focusing exclusively on companies in the energy efficiency sector, through which a number of U.S. based DSM service providers were introduced to Beijing. Jake Levine from Opower had this to say: "Opower is excited to bring its behavioral demand response technology to the EcoPartnership's important work in China. Opower is the global leader in cloud-based software for the utility industry. We are grateful to be a part of the tireless efforts that BEEC and NRDC have made to leverage American technology towards better engaging Chinese consumers and shifting peak demand. While this work remains in its early stages, Opower looks forward to participating over the long-term to be a part of a national effort to help China create a more reliable, greener, and more profitable grid."

III. PROGRESS TO DATE

A. Achievements

Since 2013, BEEC and NRDC have worked hand-in-hand to promote DSM in Beijing. The efforts of both parties resulted in the following achievements. See Figure 3 for the BEEC-NRDC implementation structure.

1. Policy framework

In order to effectively promote DSM and mobilize enterprises in the city, BEEC and NRDC helped the Beijing government develop an overall DSM incentive program policy framework based lessons learned from U.S. DSM implementation experiences. For example,

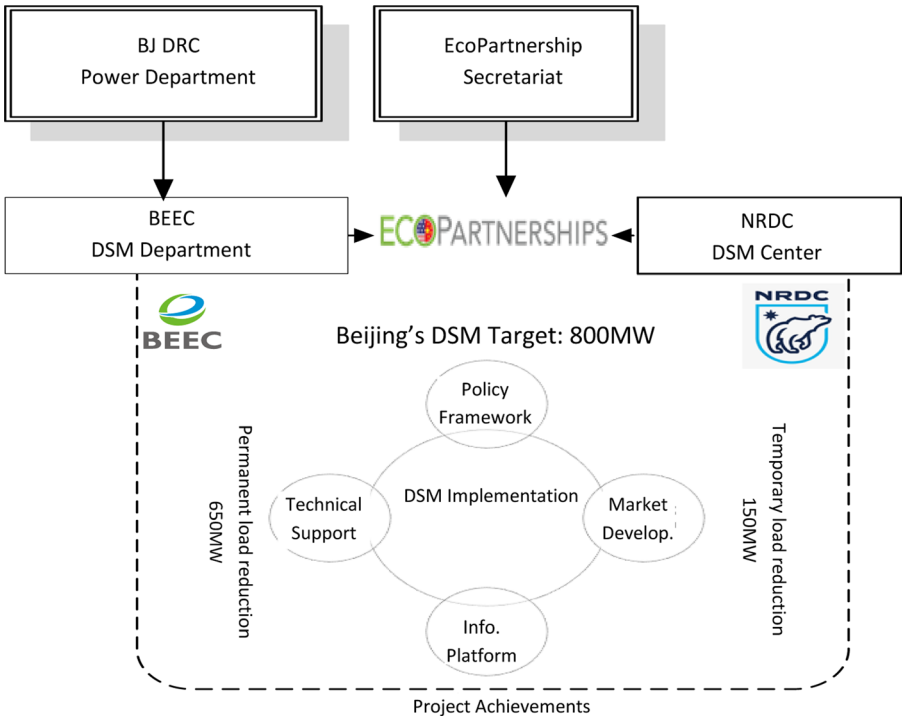

FIG. 3. BEEC-NRDC EcoPartnership implementation structure.

the model of using third party aggregators to recruit participating customers and deliver demand reduction is proven to be very successful in the U.S. and could be a good way to quickly reach a wide range of market segments in Beijing. The BEEC and NRDC researched and adapted U.S. third party aggregator models and incentive mechanisms for Beijing's use. With support from the EcoPartnership, Beijing successfully launched its DSM program which is now in its third year of implementation.

2. Dedicated DSM staffing

Drawing from U.S. DSM implementation models as reference, the BEEC established a dedicated DSM Department in December 2013 to more actively support the expansion of DSM measures in Beijing. The department's main functions include assisting power authorities in developing DSM programs and plans; coordinating the implementation of DSM projects including "efficiency power plants (EPP)" (i.e., virtual power plants that could deliver "negawatts" to offset peak demand), load management, and voluntary demand response; advancing the development of a DSM data collection and information platforms; and initiating research, trainings, and international exchanges. The establishment of a dedicated DSM department (Figure 4) within the BEEC has led to an effective integration of expert resources and enhanced the city's overall DSM capability.

3. Training and communication

China and the US have successfully promoted energy conservation and fostered a robust energy services industry. While the energy service providers in Beijing are quite familiar with the EPP concept, most lack the awareness and understanding related to DSM and in particular demand response project implementation. At the societal level, enterprises know even less about peak load reduction measures. Therefore, BEEC and NRDC designed multiple seminars and trainings for different target groups. For example, for electricity users, training courses on technology and measures were designed, and for aggregators, seminars on demand response

FIG. 4. Beijing DSM staff.

implementation models and user development were provided. The surveys conducted after each training showed positive results along with positive feedback—we found that some trainees not only understood the training content but were able to present the concepts learned to other audiences as well. These targeted trainings have helped raise Beijing's overall DSM implementation capabilities and improved the proficiency of electricity services companies[10] in providing specialized energy efficiency and demand response services.

4. DSM implementation

Beijing's 800 MW DSM target includes 650 MW of permanent peak load reduction and 150 MW of temporary load reduction. During the first 2 years, Beijing's focus has been on recruiting projects for permanent load reduction. Three calls for projects in 2013 and 2014 resulted in 300 projects totaling 280 MW so far, and additional projects are currently being evaluated for acceptance. Beijing developed a demand response program in 2015 to secure temporary load reduction. Potential third party demand response aggregators responded enthusiastically, and customer recruitment is underway.

To achieve the city's permanent power load reduction target, Beijing appealed to industrial, commercial, and public buildings to implement peak load reduction projects. These covered a wide range of technologies, including energy efficient lighting, motor replacement, motor drive and speed adjustment, air conditioner modification and optimization, transformer replacement, heat pumps, reactive compensation, energy-saving transformation for production processes, thermal storage heating, and water and ice cool storage air-conditioning. Participants in this category included industrial companies, schools, hospitals, marketplaces, and property managers, especially large public buildings.

As mentioned earlier, Beijing elected to engage third party demand response aggregators to help achieve its temporary load reduction target. While industrial facilities can easily achieve large load reduction using simple practices such as adjusting production plans and shutting down unnecessary electricity equipment, the predominance of commercial buildings in Beijing means that much greater efforts would be needed to reach the same amount of savings. Through third party aggregators, Beijing is able to deploy multiple channels to reach a larger number of customers. The NRDC-BEEC EcoPartnership has been instrumental in introducing the aggregator concept to Beijing as well as in helping to recruit and train third party aggregators. Beijing has now established a pool of qualified aggregators who will implement Beijing's 2015 demand response program to be rolled out this summer.

5. DSM data collection and information platform

Enabled by modern computing and network technologies, Beijing created a data collection and information platform—the DSM Service Platform (see Figure 5)—which provides real-time power consumption monitoring, economic analysis capabilities, DSM implementation support and information services. This platform is central to Beijing's demand response efforts in 2015: Power authorities will issue load reduction signals to end-users and third party aggregators via

the platform, as well as monitor and verify the reported load reduction using data collected through the platform. The demand response module within the DSM Service Platform was developed through a series of in-depth and interactive discussions among key government and industry stakeholders. BEEC and NRDC also actively worked with the platform's developers to provide input from the perspectives of aggregators and others.

6. China-U.S. information exchange and cooperation

The BEEC-NRDC EcoPartnership served as an information exchange platform to bring the United States' DSM technologies and experiences into China. This platform enabled BEEC and NRDC to invite US experts to Beijing to share U.S. DSM design and implementation experiences, and also enabled U.S. companies to explore DSM project potential and cooperation opportunities with local partners in China. Specifically, the U.S. has developed a robust demand response market with many experienced aggregators, some of whom have expressed interest supporting and participating in Beijing's demand response program. While Beijing has expressed its welcome, the process for entering a new country takes time, and it will take time for U.S. companies to make substantive progress. The BEEC-NRDC EcoPartnership will continue to serve as a conduit for enhancing communication between the two countries and help introduce U.S. companies and technologies to the city. The infusion of U.S. resources could provide strong support for the development of the electricity services market in Beijing.

B. Challenges

Even with strong government support, Beijing is grappling with a number of practical implementation challenges, which are briefly described below.

1. Nascent support system

The city government has issued polices to guide the implementation of load reduction projects. However, DSM is still a relatively new concept compared to energy saving and emission reduction, and DSM implementation require coordination among multiple stakeholders related to different issues such as funding, measurement, and evaluation. The city needs to further develop a coordinated support mechanism to help carry out DSM practices.

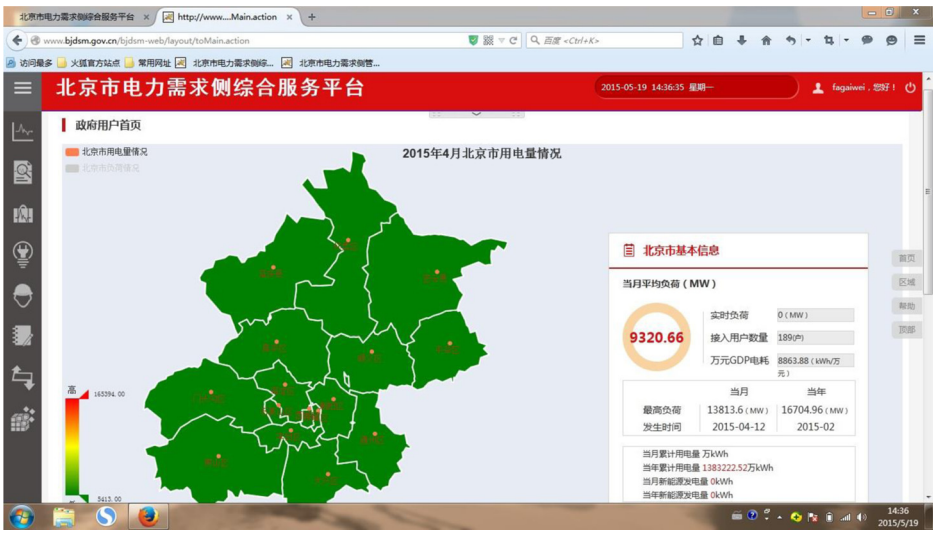

FIG. 5. Beijing DSM platform.

2. Delays in payment processing

The availability of financial subsidies played a critical role in recruiting participants initially, but post-project delays in payment processing has impeded progress in scaling up the program. While the central government has allocated funding for Beijing's program, the procedures for receiving the subsidies are complex and lengthy. This has reduced the motivation of potential participants to invest in DSM projects.

3. Slow pace of electricity services market development

Some energy services companies in Beijing already have sufficient capability to carry out efficiency power plant projects, but many lack the capacity to serve as aggregators. The general DSM knowledge and awareness level is low, and Beijing needs to explore additional mechanisms drive the electricity services market development. The power service market is growing too slowly to scale up demand response projects in Beijing.

4. Low awareness among electricity users

As with energy services providers, the electricity users in the city have a good understanding of energy and electricity conservation but a relatively low level of knowledge about DSM practices. Disbursed incentives and lack of technical assistance have also contributed enterprises' low motivation to implement DSM, thus impeding progress toward Beijing's DSM goal achievement.

IV. ECOPARTNERSHIP IS HELPING TO DEVELOP A GREEN MODEL FOR POWERING BEIJING

The cooperative efforts of the BEEC-NRDC EcoPartnership are already providing some valuable lessons learned. Three factors are especially important if Beijing is to move toward a green power model: strong government support, especially at the initiation stage of a newly introduced program such as demand response; a developed electricity services market, which will assist the government in implementing programs successfully; and high public awareness, which helps to form an environment conducive to considering, implementing, and integrating DSM a resource.

BEEC and NRDC will help address the challenges described above by continuing to build on the EcoPartnership cooperation framework and further providing policy research, training and communication, and technical support to power Beijing in a sustainably green way.

A. Near term efforts

Additional research will be conducted to address the challenges identified above, such as demand response implementation models, measurement and verification of load reductions, verification methods, cost-benefit analyses, and so on. In particular, a comprehensive cost-benefit analysis can help quantify the costs and benefits to grid companies, project implementers, and the government to facilitate project acceptance.

To further build the capacity of Beijing's electricity service market, increase the number of DSM platform participants, and expand technical support to end users, BEEC and NRDC will organize seminars, study tours, and visits to strengthen the exchange and cooperation between relevant organizations in China and the U.S. These activities will be designed to promote the sharing of practical experience, technologies, and products to build a robust DSM market with capable electricity service providers and innovative technical products.

B. Long term outlook

Beijing is planning to continue its DSM efforts after the three-year pilot program ends, due to its growing electricity consumption and summer peak constraints and in accordance with

China's power sector reform guidance. The BEEC-NRDC EcoPartnership has provided a solid foundation on which to build a long term, sustainable DSM mechanism in Beijing. Beijing's best practices and also lessons learned will be widely communicated with policymakers and industry stakeholders as part of the BEEC-NRDC EcoPartnership, so that Beijing's successes can be replicated by other cities in China as well as the U.S.

V. CONCLUSION

The China-U.S. EcoPartnership has provided an excellent platform for exchange and cooperation. Through the BEEC-NRDC EcoPartnership, Beijing has developed a policy support framework for DSM, launched the DSM Service Platform, and created an electricity services and third party demand response aggregator market. These achievements provide the foundation for Beijing to achieve its target. BEEC and NRDC will continue to leverage the two organizations' respective resources and strengths to help Beijing achieve its 800 MW peak load reduction target. While some challenges remain, Beijing, with the support of the EcoPartnership, is well on its way to access a green power supply through DSM.

[1]Ministry of Finance, Interim Measures on Financial Incentives from the Central Government for Demand-Side Management Pilot Program, 3 July 2012.
[2]Ministry of Finance, National Development and Reform Commission, Announcement Regarding Selection of First Set of DSM Pilot Cities, 2012.
[3]Beijing Development and Reform Commission, Notice on Implementing Beijing's Integrated DSM Pilot Project Work, 17 July 2013.
[4]National Development and Reform Commission, Demand Side Management Measures, 18 November 2010.
[5]State Council, State Council Document Number 9 (2015) Opinions on Deepening Power System Reform, State Council, 15 March 2015.
[6]Beijing Municipal Environmental Protection Bureau, Release of Beijing PM2.5 Source Analysis, 2014.
[7]Beijing Municipal Government, Beijing Municipal Clean Air Action Plan 2013–2017, 2013.
[8]The Demand Side Management Rules issued on November 4, 2010 required China's grid companies to meet annual energy efficiency savings and demand reduction targets starting in 2011.
[9]The State Council's Opinions on Deepening Power System Reform released on March 16, 2015 provides specific guidance pertaining to DSM implementation.
[10]Electricity service companies refer to professional agencies providing electricity services, including both ESCOs (energy service companies) and aggregators, which provide demand response services.